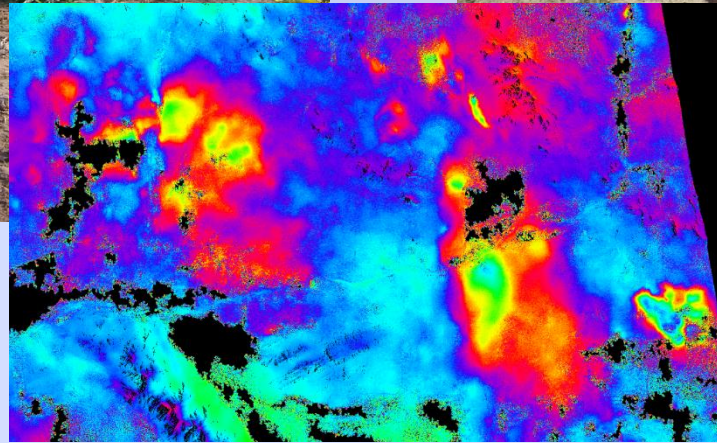
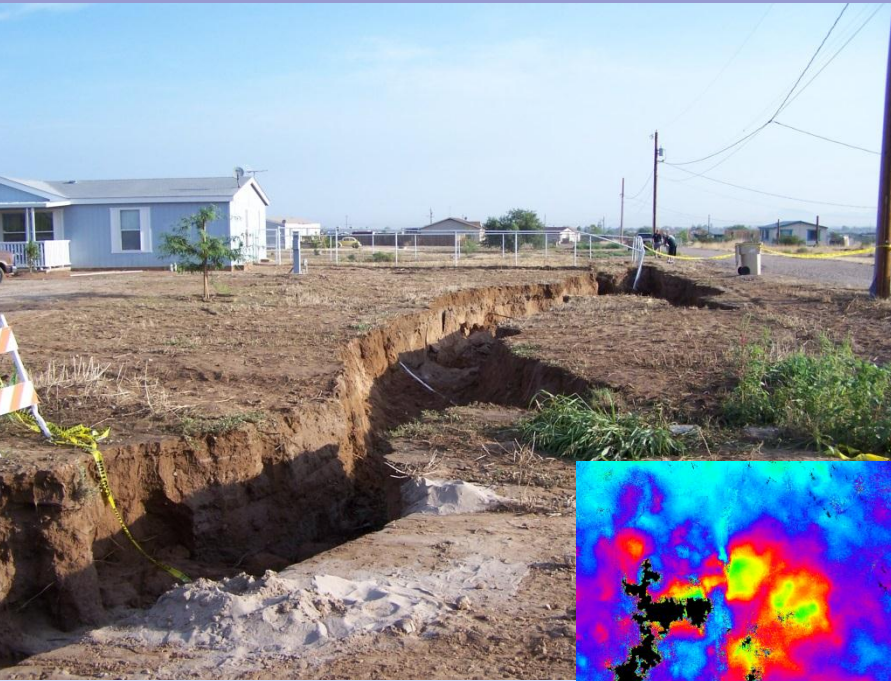


# Arizona Department of Water Resources Land Subsidence Monitoring Program Interferometric Synthetic Aperture Radar (InSAR)



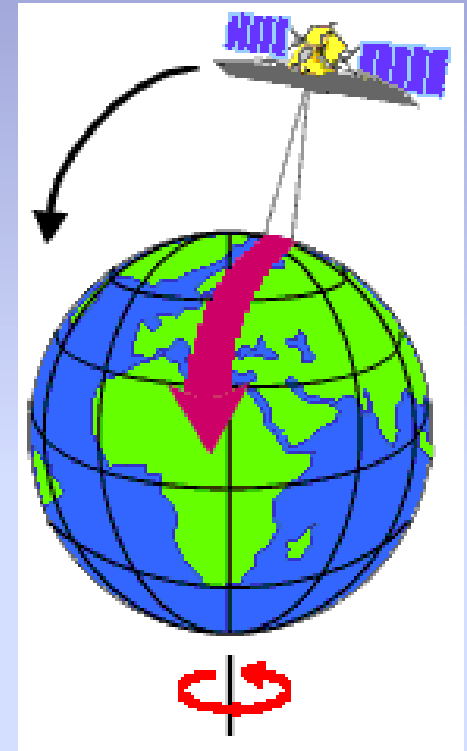
Brian D. Conway  
Hydrologist/Supervisor  
Geophysics-Surveying Unit



Phoenix AMA GUAC Meeting, November 14, 2013

# Synthetic Aperture Radar (SAR)

- Active sensor (day/night/clouds)
- Near Circular, Polar Orbit
- Repeat cycle 8-46 days
- Satellites need to be tasked

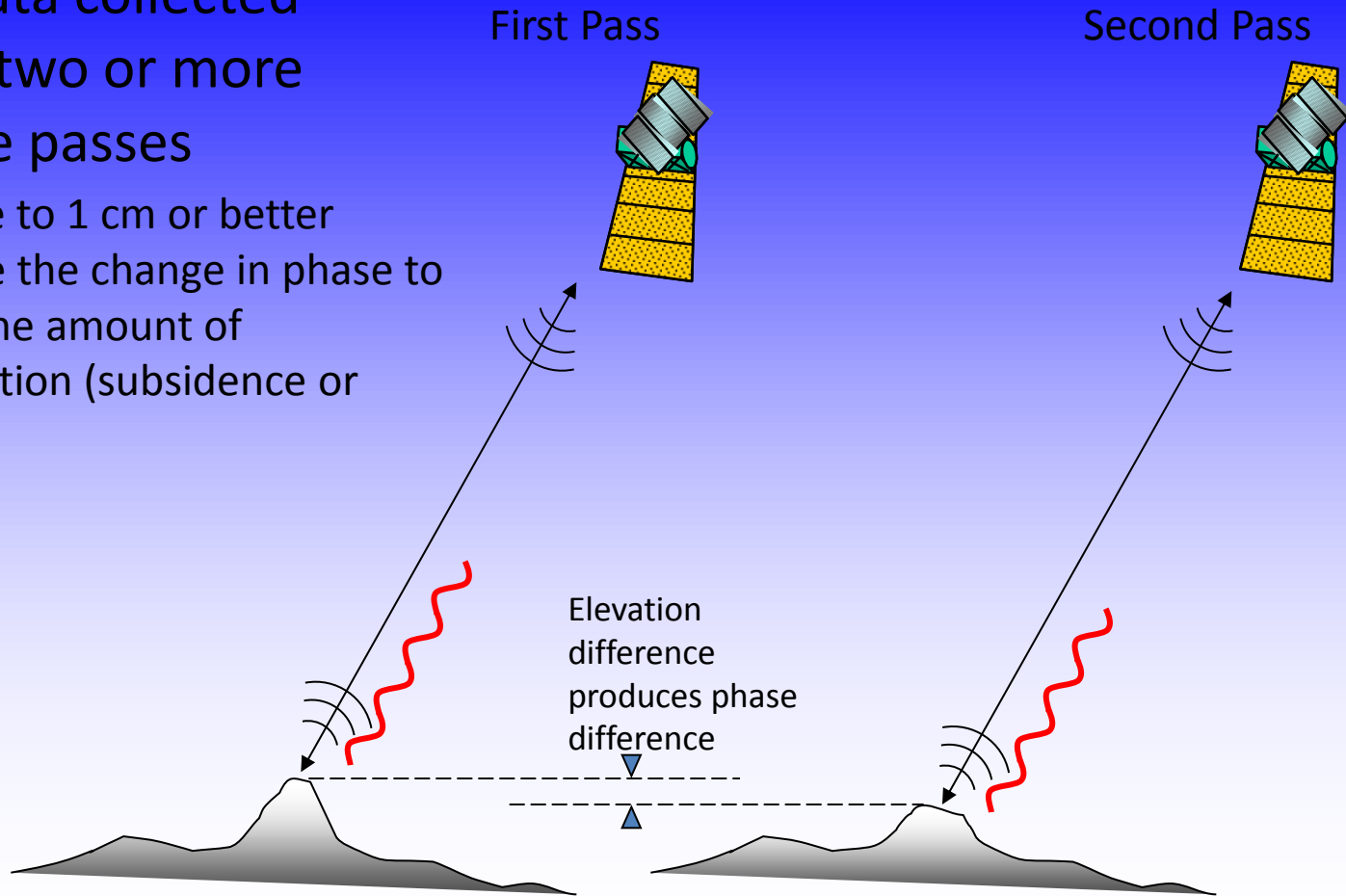


# Differential Synthetic Aperture Radar (DiffSAR)

## Process SAR Data Using Interferometry

Uses data collected during two or more satellite passes

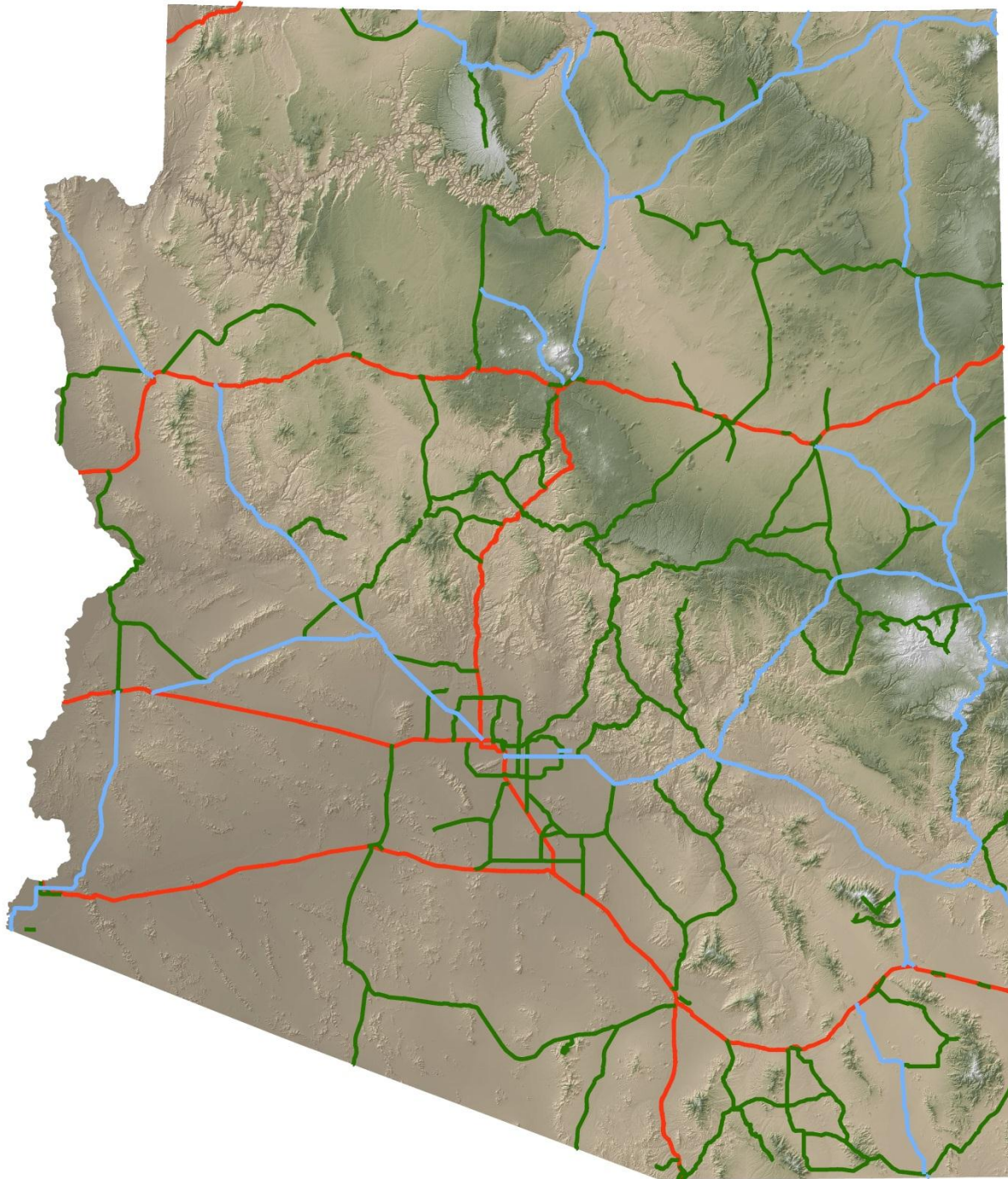
- Accurate to 1 cm or better
- Measure the change in phase to determine amount of deformation (subsidence or uplift)





# ADWR InSAR Program

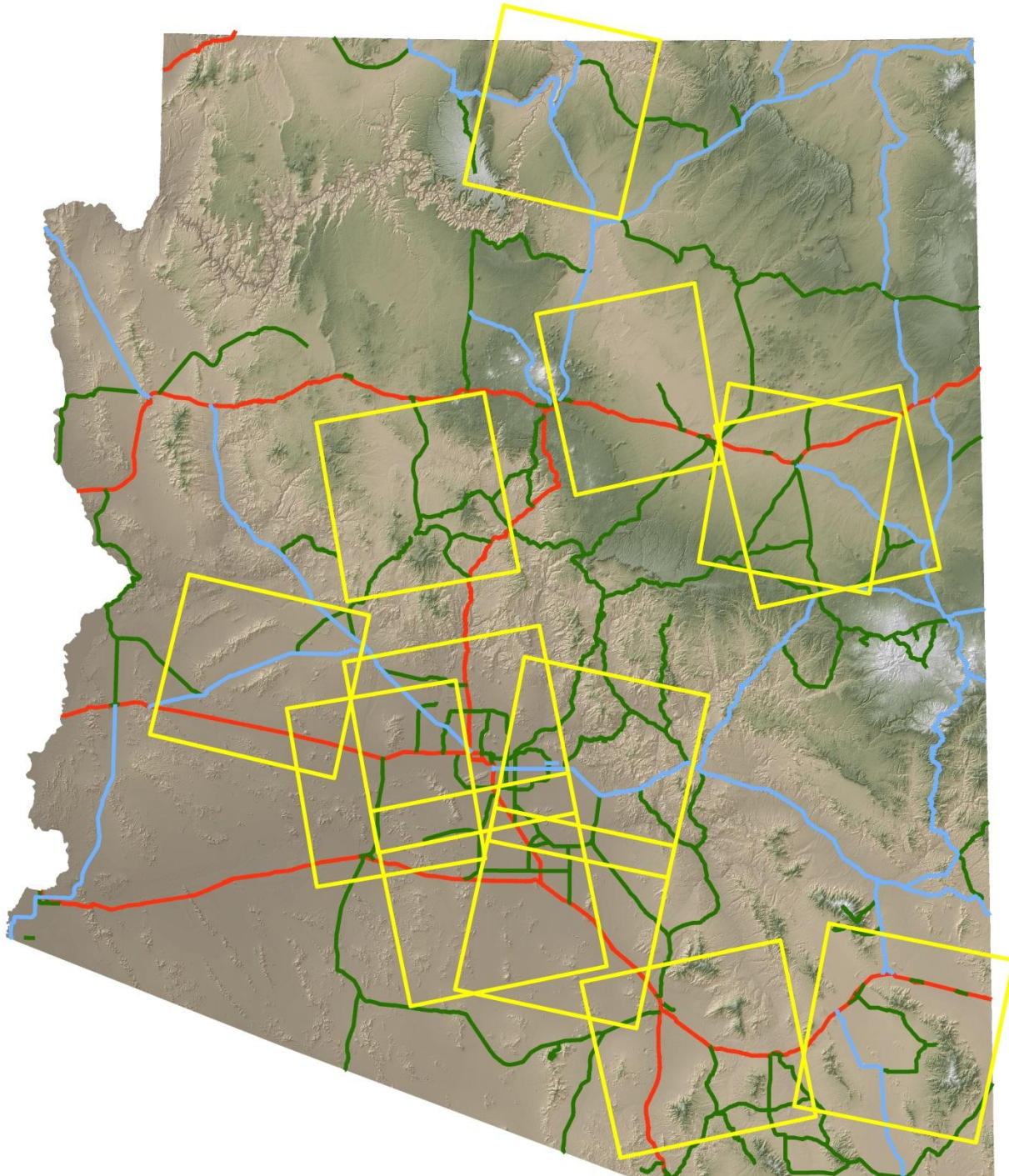
- Fully Operational in 2005 (Completion of 3-Year NASA Grant)
- Started collecting data over the Phoenix and Tucson AMA's
- Program has been expanded to cover the entire state through external cooperative funding





# ADWR InSAR Program

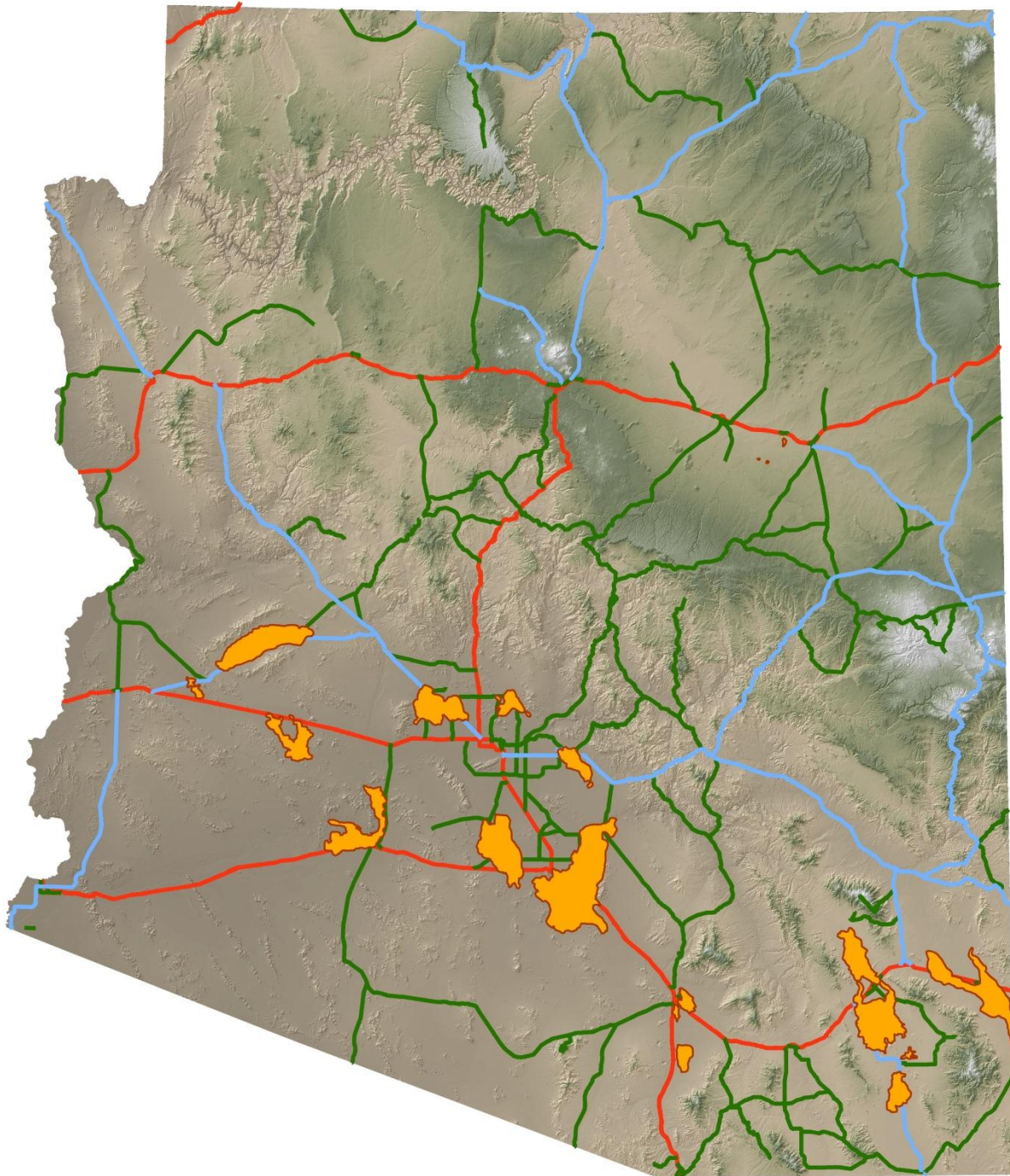
- Program has been expanded to cover the entire state and fully funded through external cooperative agreements with more than 13 Federal, State, County, and Local Agencies
- Collect InSAR data over more than 50,000 square miles





# ADWR InSAR Program

- Identified more than twenty-five individual land subsidence features that cover more than 1,100 square miles
- Provide land subsidence maps covering various periods of time on ADWR's website

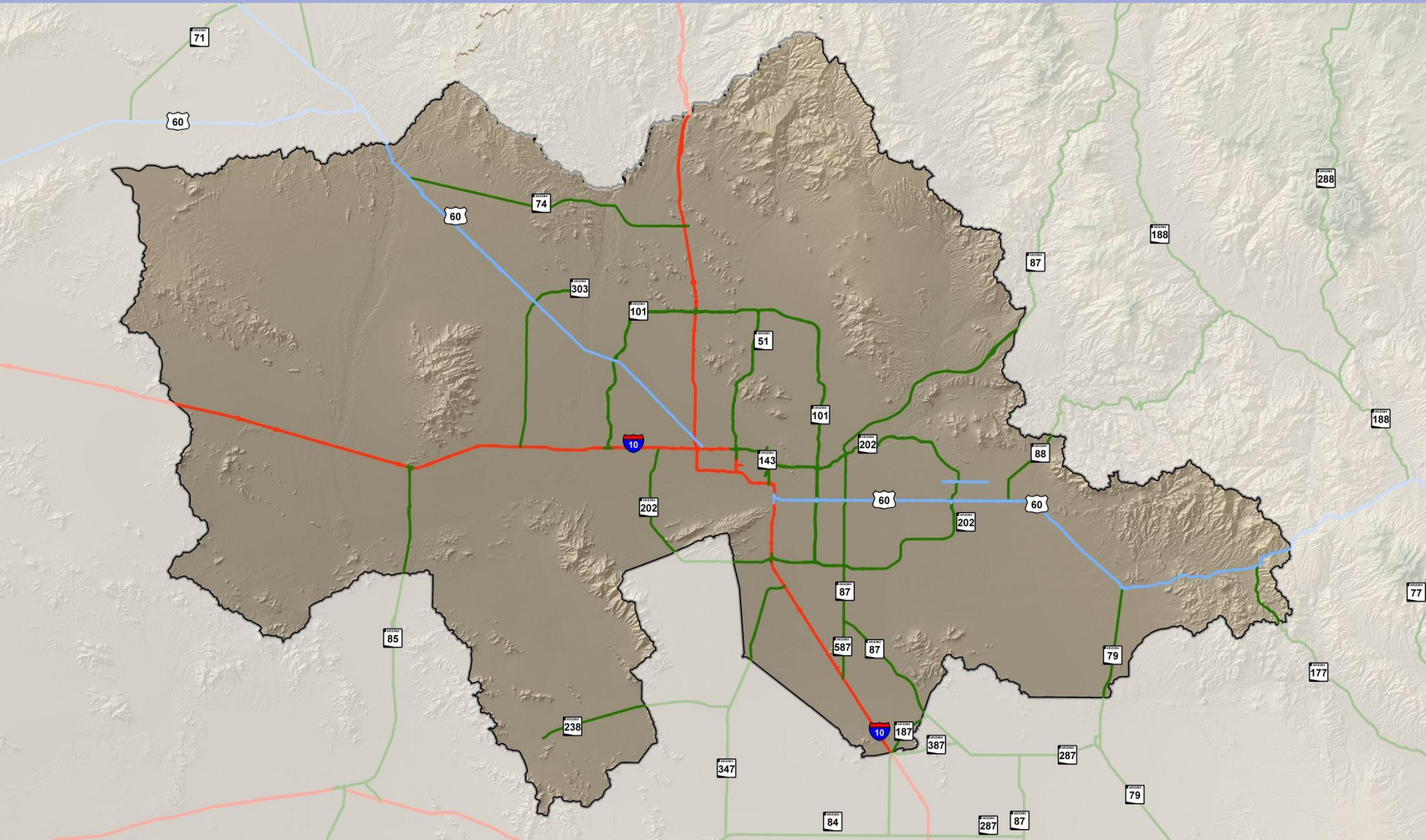


# **ADWR InSAR Program Cooperators**

- **Flood Control District of Maricopa County**
- **Pinal County Flood Control District**
- **Arizona Department of Transportation**
- **Arizona State Land Department**
- **Central Arizona Project**
- **Metropolitan Domestic Water Improvement District**
- **Salt River Project**
- **Community Water Company**
- **City of Scottsdale**
- **Cochise County**
- **Arizona Geological Survey**
- **Petrified Forest National Park**
- **City of Phoenix (Verbal Commitment)**



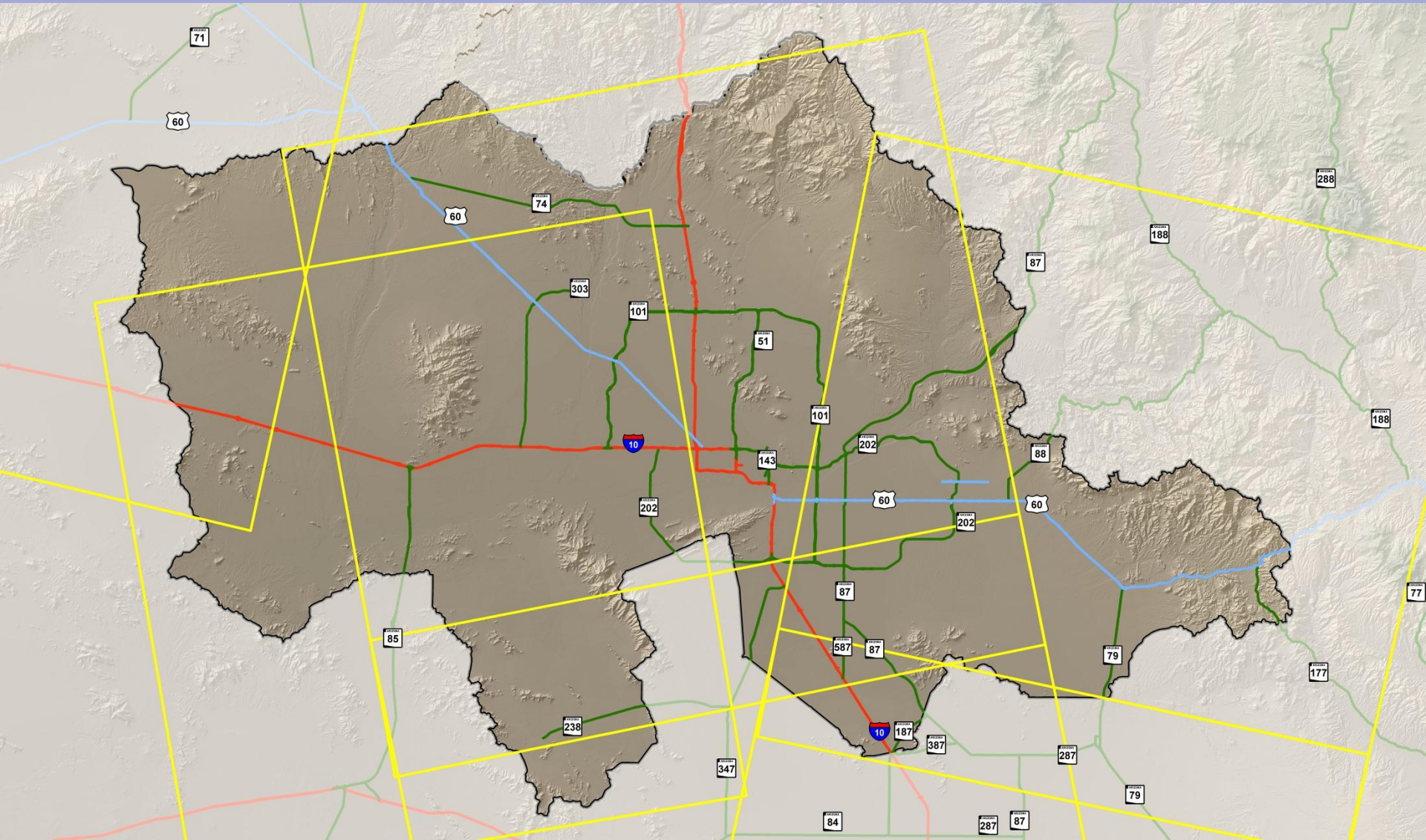
# Land Subsidence Monitoring in the Phoenix AMA





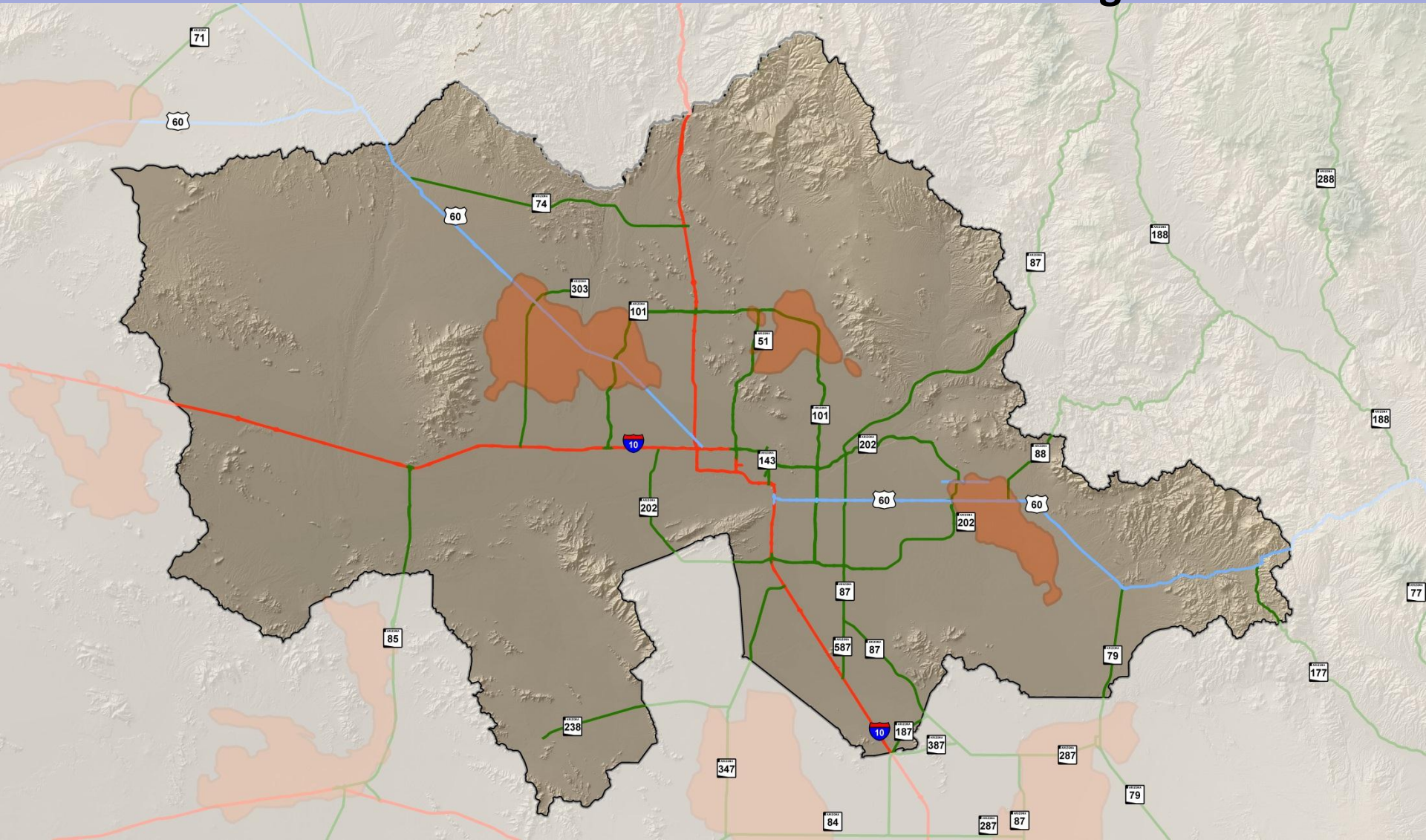
# Land Subsidence Monitoring in the Phoenix AMA

## InSAR Frames That Cover the Phoenix AMA



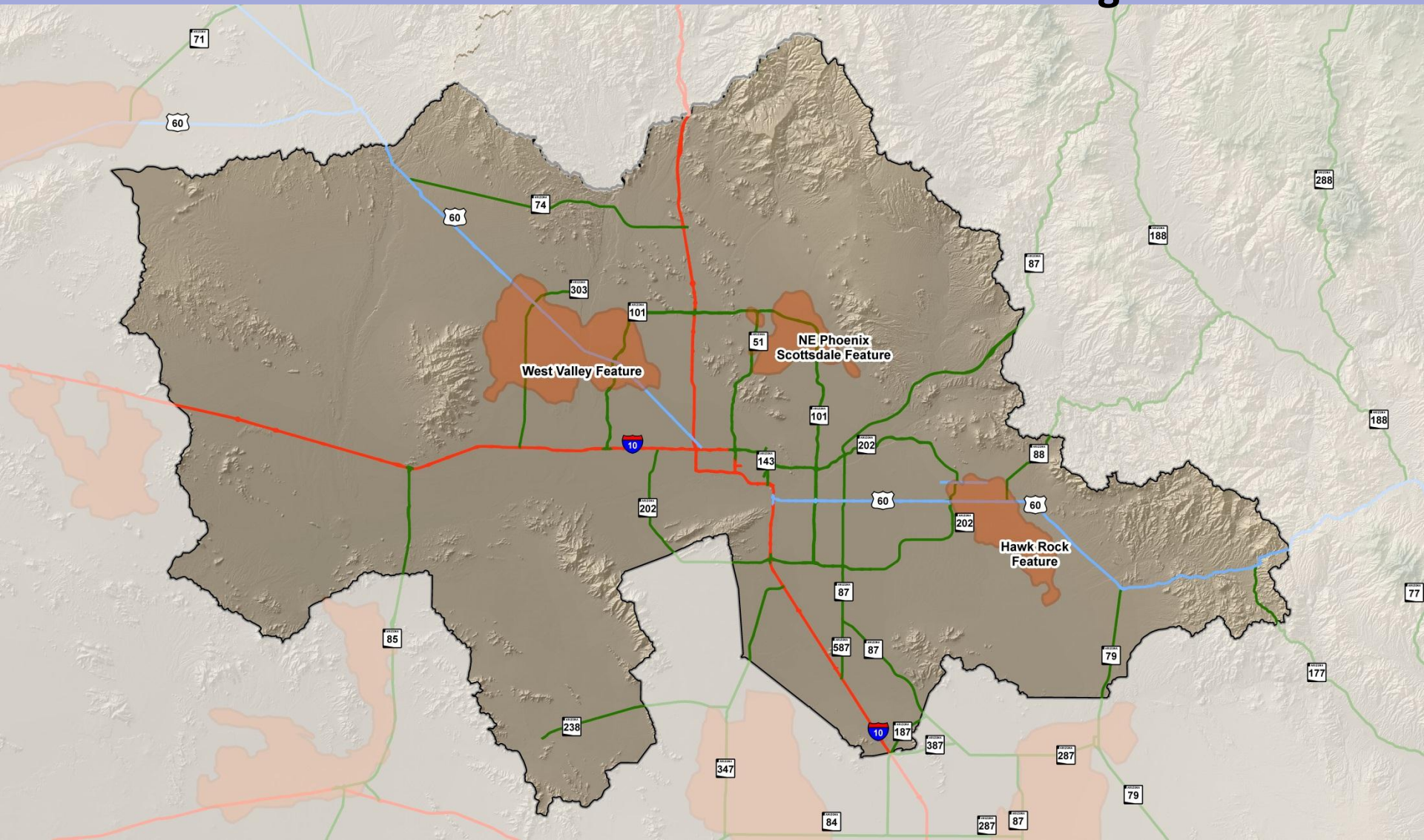


## Three Land Subsidence Features Identified and Being Monitored





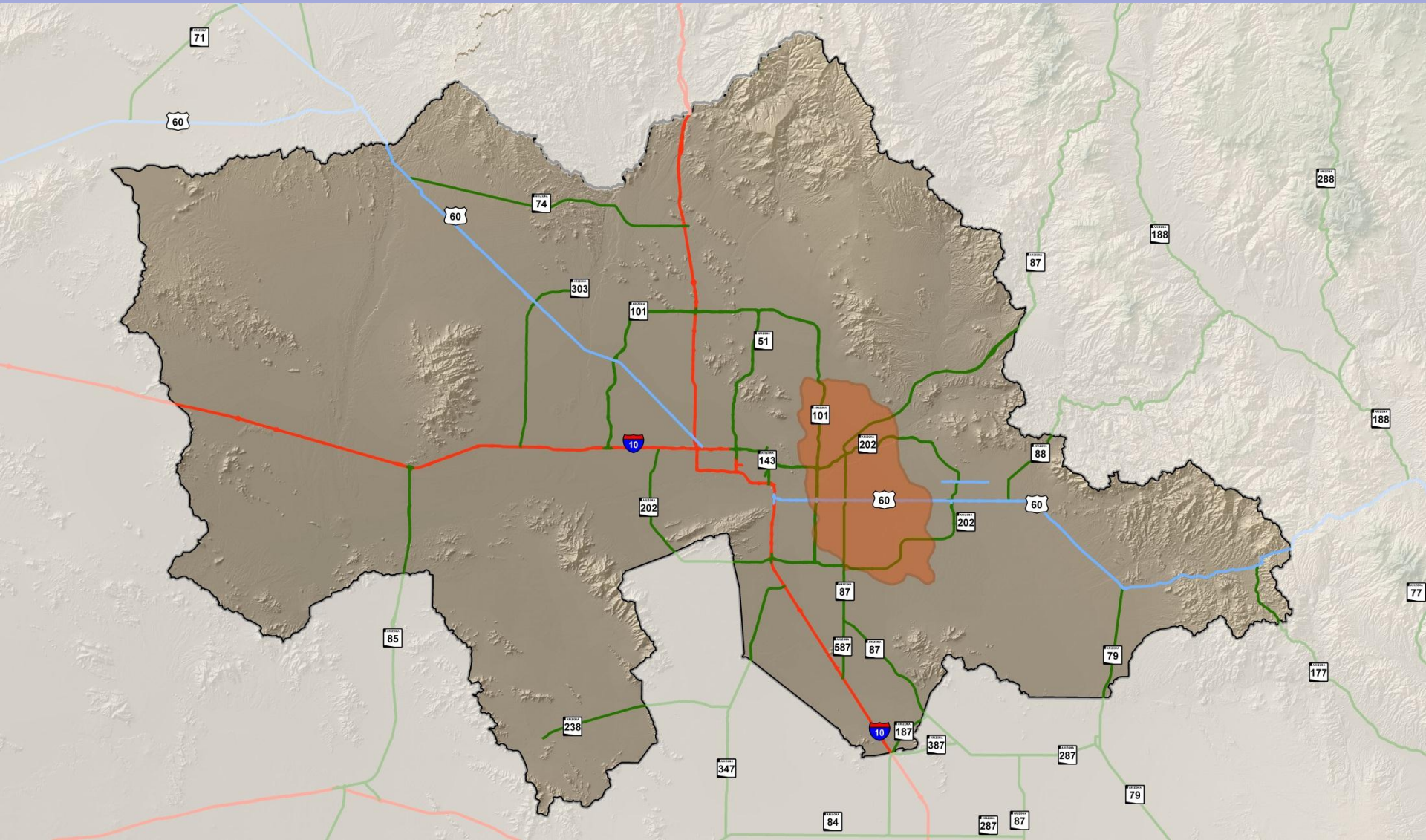
## Three Land Subsidence Features Identified and Being Monitored





# Land Subsidence Monitoring in the Phoenix AMA

## Recently Identified New Land Subsidence Feature



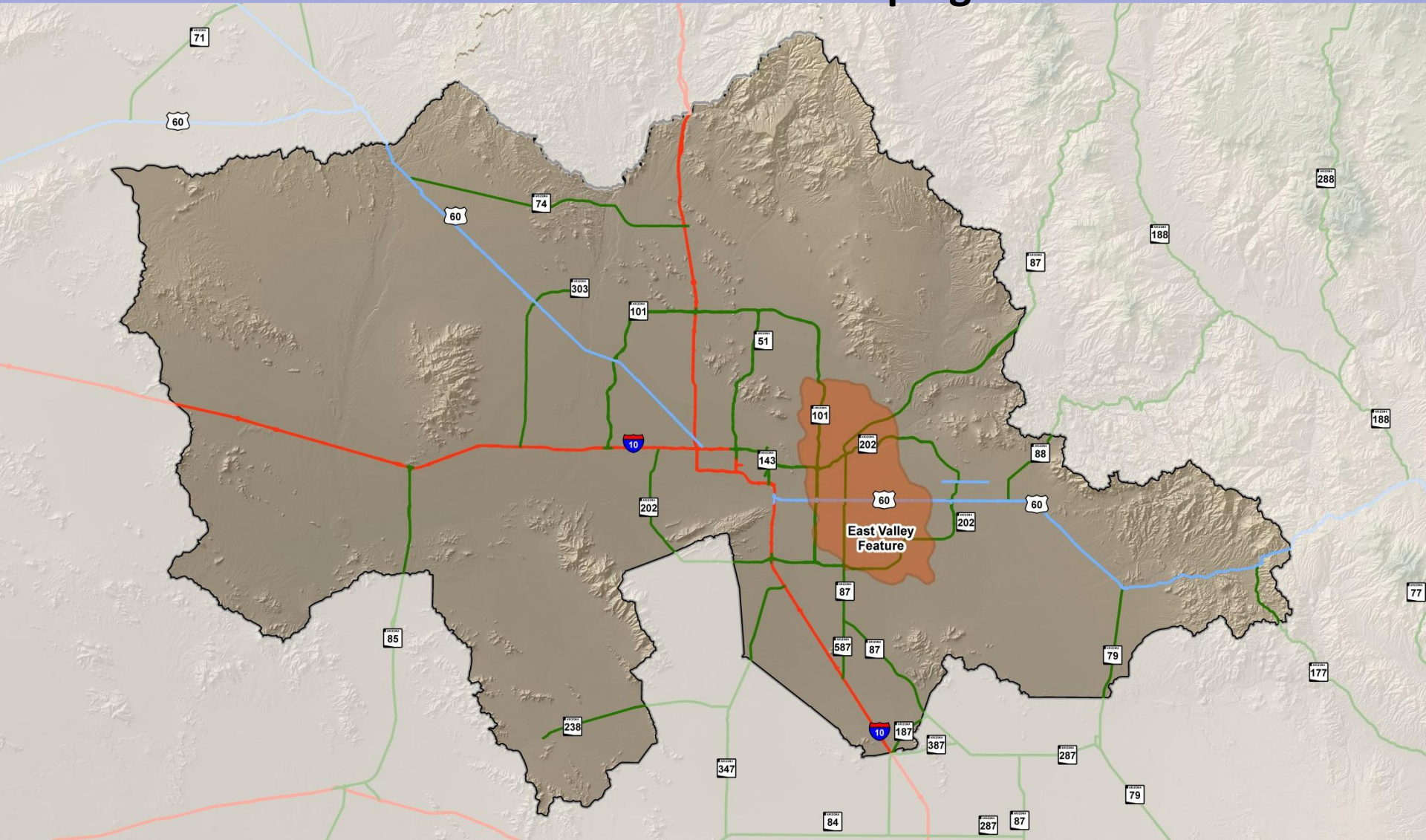


# Land Subsidence Monitoring in the Phoenix AMA

## Recently Identified New Land Subsidence Feature

### East Valley Feature

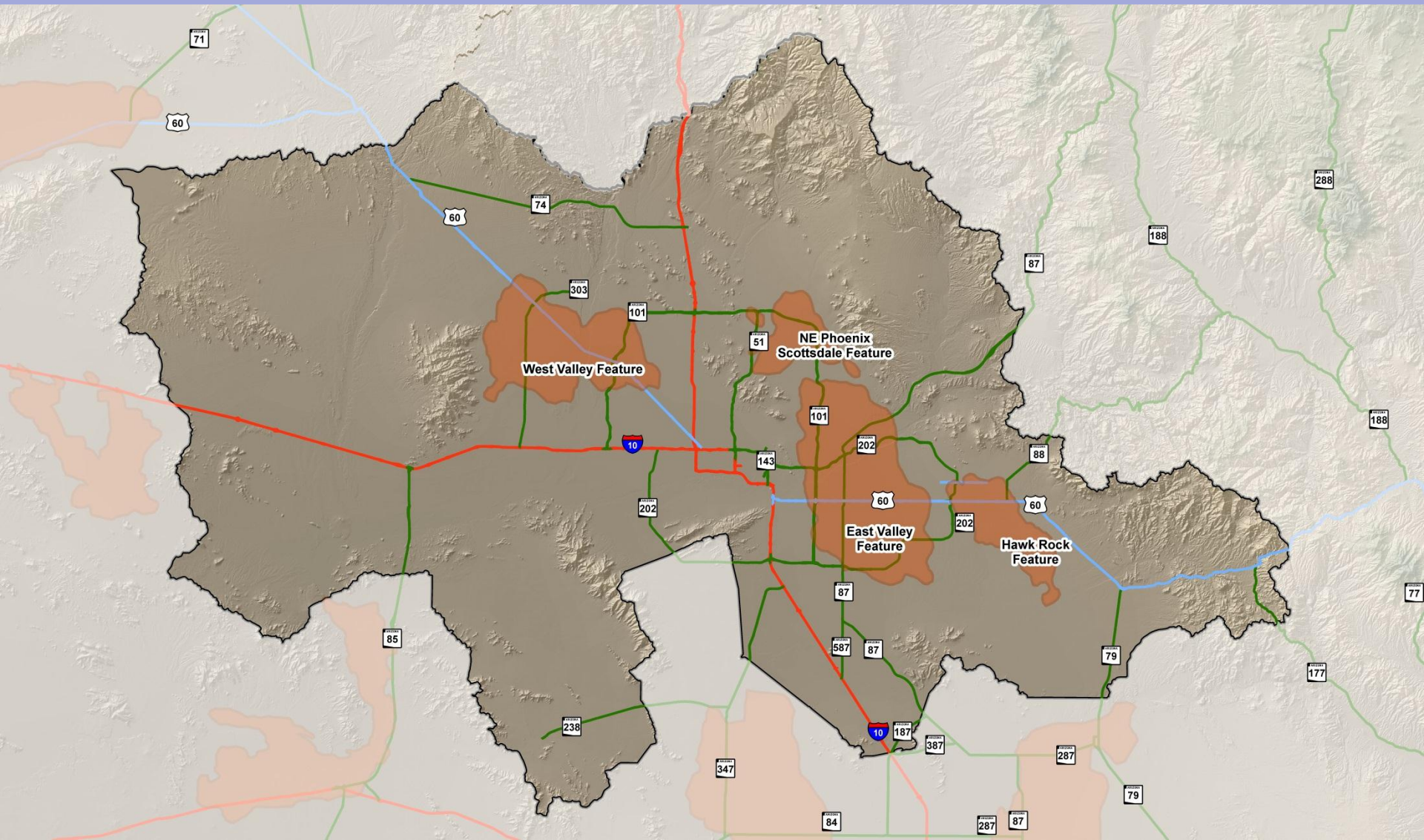
#### A Result of Recent Increased Pumping in the Area





# Land Subsidence Monitoring in the Phoenix AMA

## Four Land Subsidence Features Identified and Being Monitored





# ADWR's Land Subsidence Website



[Geophysics/Surveying Unit Home](#) | [GPS](#) | [Gravity](#) | [Reports, Maps, and Images](#) | [InSAR](#) | [Land Subsidence in Arizona](#) | [Contact Us](#)

## Land Subsidence in Arizona

### *In the News...*

Recently the Department has begun working with NASA's Jet Propulsion Laboratory to collect data through NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) program in Cochise County to improve data collection and to complement the Department's satellite-based Interferometric Synthetic Aperture Radar (InSAR) data. The Arizona Department of Water Resources has been collecting and processing InSAR data since 2002 to monitor land subsidence throughout Arizona. The Department has identified more than 25 land subsidence features that cover more than 1,100 square miles.

### **[NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar News Release](#)**

**[Radar Plane Scans South American Landscapes](#)** (Yahoo! News)

### **[NEW! Interactive Arizona Land Subsidence Map](#)**

#### Arizona Land Subsidence Areas

<a href="#">Scottsdale/NE Phoenix</a>	<a href="#">McMullen Valley</a>	<a href="#">Picacho/Eloy</a>	<a href="#">Fort Grant Rd</a>
<a href="#">West Valley</a>	<a href="#">Harquahala Valley</a>	<a href="#">Maricopa-Stanfield</a>	<a href="#">Kansas Settlement</a>
<a href="#">Hawk Rock</a>	<a href="#">Ranegras Valley</a>	<a href="#">Tucson</a>	<a href="#">Elfrida</a>
<a href="#">Buckeye</a>	<a href="#">Gila Bend</a>	<a href="#">Green Valley</a>	<a href="#">Bowie/San Simon</a>
<a href="#">Holbrook Sinks</a>			

### **[What is Land Subsidence](#)**

# ADWR's Land Subsidence Website



[Geophysics/Surveying Unit Home](#) | [GPS](#) | [Gravity](#) | [Reports, Maps, and Images](#) | [InSAR](#) | [Land Subsidence in Arizona](#) | [Contact Us](#)

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[NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar News Release](#)  
[Radar Plane Scans South American Landscapes](#) (Yahoo! News)

Click on Land  
Subsidence Feature

**NEW!** [Interactive Arizona Land Subsidence Map](#)

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<a href="#">Holbrook Sinks</a>			

**What is Land Subsidence**

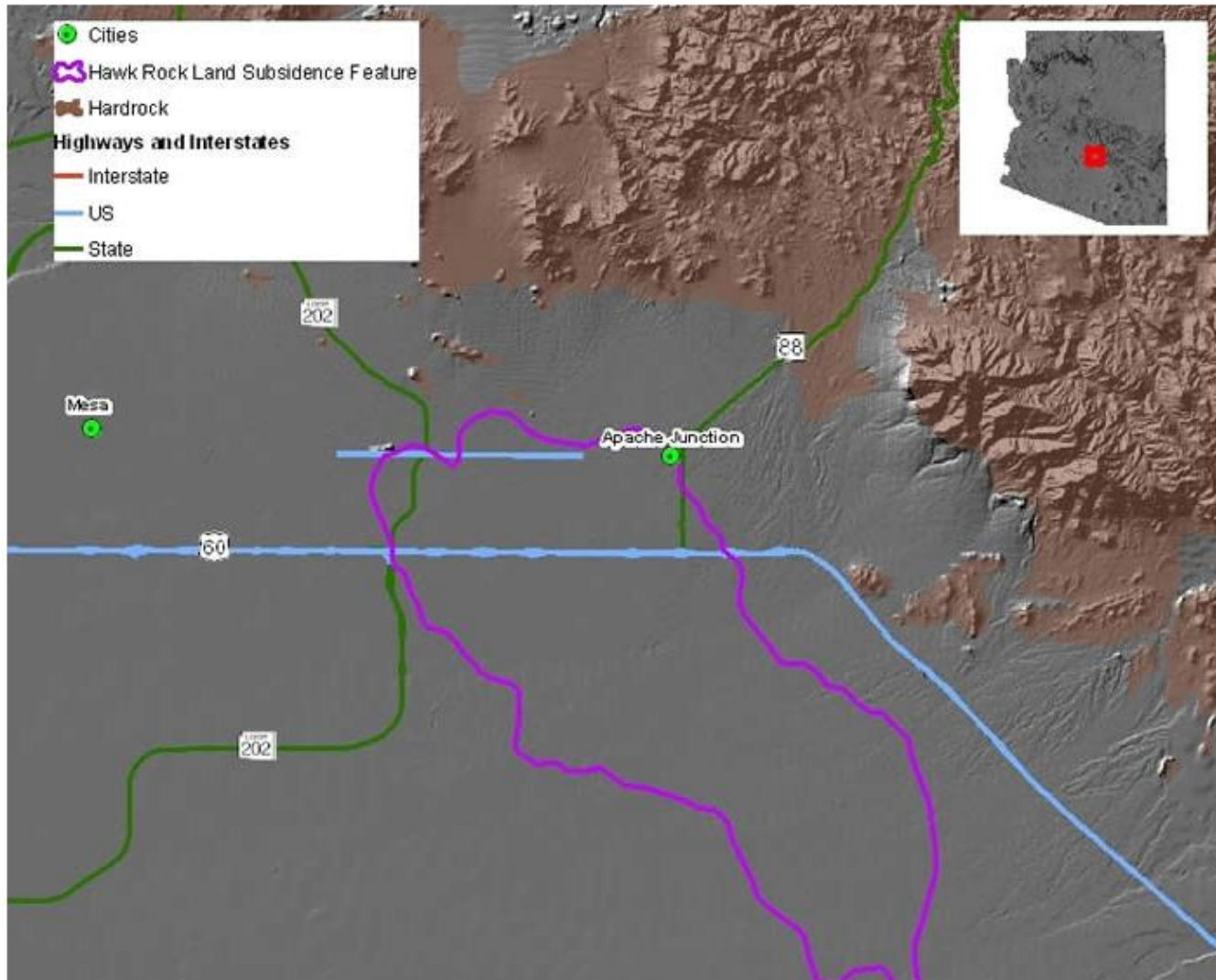


# ADWR's Land Subsidence Website

## Example of a Land Subsidence Feature Webpage

### Hawk Rock Land Subsidence Feature

#### Hawk Rock Land Subsidence Feature



# ADWR's Land Subsidence Website


## Example of a Land Subsidence Feature Webpage

### Hawk Rock Land Subsidence Feature

#### List of Available Land Subsidence Maps

The Hawk Rock land subsidence feature is located in Eastern Maricopa and Western Pinal Counties. The cities of Mesa and Apache Junction are located within the land subsidence feature along with unincorporated State Trust and private lands.

#### Land Subsidence Maps:

<a href="#">MAY-1992 to APR-2000</a> 	<a href="#">FEB2007 to APR-2008</a> 	<a href="#">JAN-2008 to MAR-2010</a> 
<a href="#">JAN-2004 to SEP-2010</a> 	<a href="#">FEB-2007 to MAR-2009</a> 	<a href="#">FEB-2009 to MAR-2010</a> 
<a href="#">FEB-2006 to APR-2008</a> 	<a href="#">JAN-2008 to FEB-2009</a> 	<a href="#">MAY-2010 to MAY-2011</a> 
<a href="#">MAR-2011 to APR-2012</a> 	<a href="#">MAY-2010 to APR-2012</a> 	<a href="#">MAR-2011 to APR-2013</a> 
<a href="#">APR-2012 to APR-2013</a> 	<a href="#">MAY-2010 to APR-2013</a> 	

#### Hydrology Division Navigation Links

[Hydrology Division Home Page](#) | [eLibrary](#) | [Basic Data Unit](#) | [Geophysics Surveying Unit](#) | [Modeling Section](#) | [Regional Planning Section](#)

Use the above links to navigate the Hydrology Division



# ADWR's Land Subsidence Website

## Example of an Land Subsidence Feature Webpage

### Hawk Rock Land Subsidence Feature

#### List of Available Land Subsidence Maps

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**Land Subsidence Maps:** **Click on Land Subsidence Map**

<a href="#">MAY-1992 to APR-2000</a> 	<a href="#">FEB2007 to APR-2008</a> 	<a href="#">JAN-2008 to MAR-2010</a> 
<a href="#">JAN-2004 to SEP-2010</a> 	<a href="#">FEB-2007 to MAR-2009</a> 	<a href="#">FEB-2009 to MAR-2010</a> 
<a href="#">FEB-2006 to APR-2008</a> 	<a href="#">JAN-2008 to FEB-2009</a> 	<a href="#">MAY-2010 to MAY-2011</a> 
<a href="#">MAR-2011 to APR-2012</a> 	<a href="#">MAY-2010 to APR-2012</a> 	<a href="#">MAR-2011 to APR-2013</a> 
<a href="#">APR-2012 to APR-2013</a> 	<a href="#">MAY-2010 to APR-2013</a> 	

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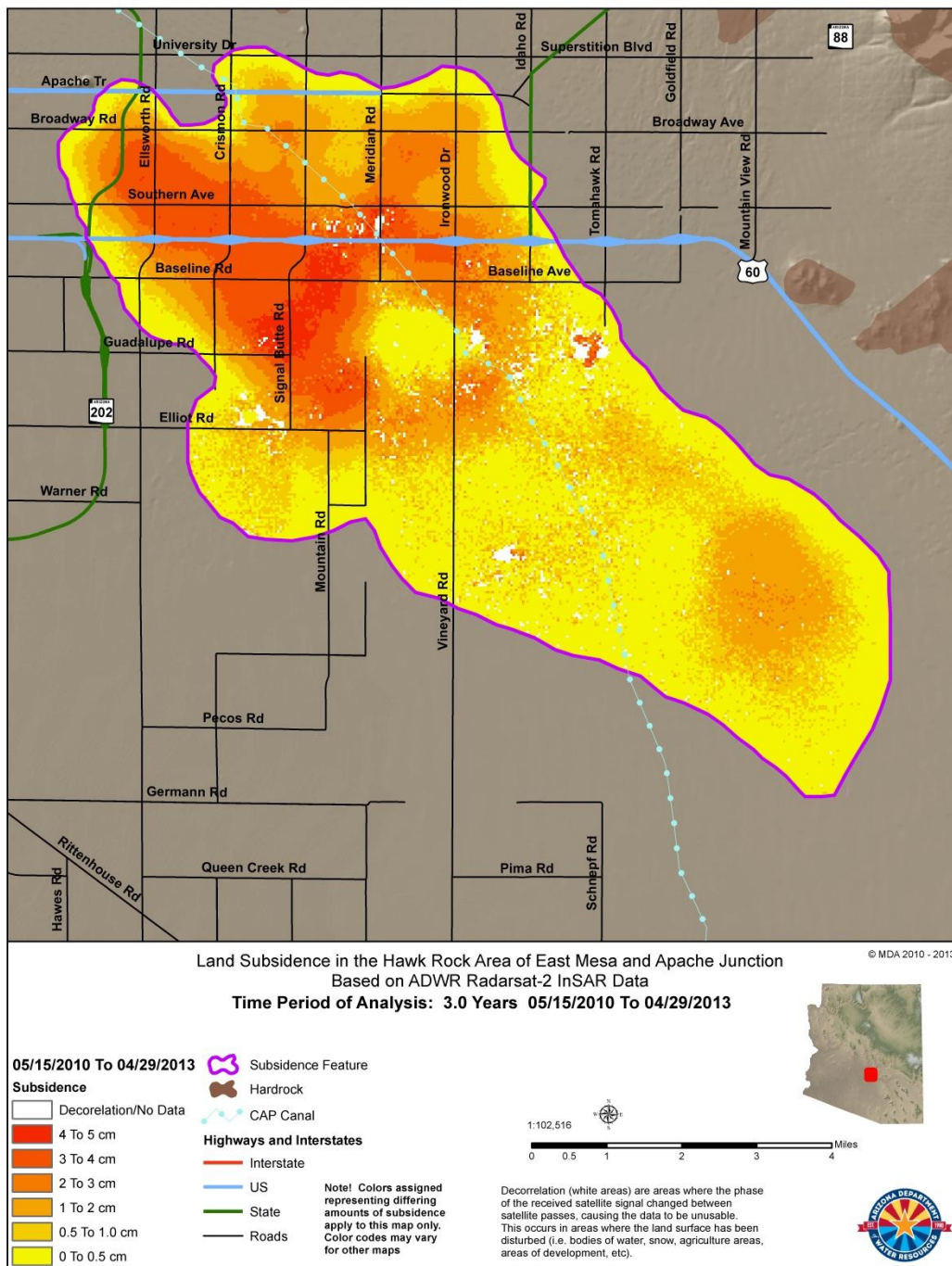
# ADWR InSAR Program

An example of a land subsidence  
PDF map: Hawk Rock 2010-2013

Land subsidence as high as 5 cm  
in 3-years

Land subsidence maps are  
updated annually (late  
spring/early summer)

As of May 2013, more than 160  
land subsidence maps are  
available online

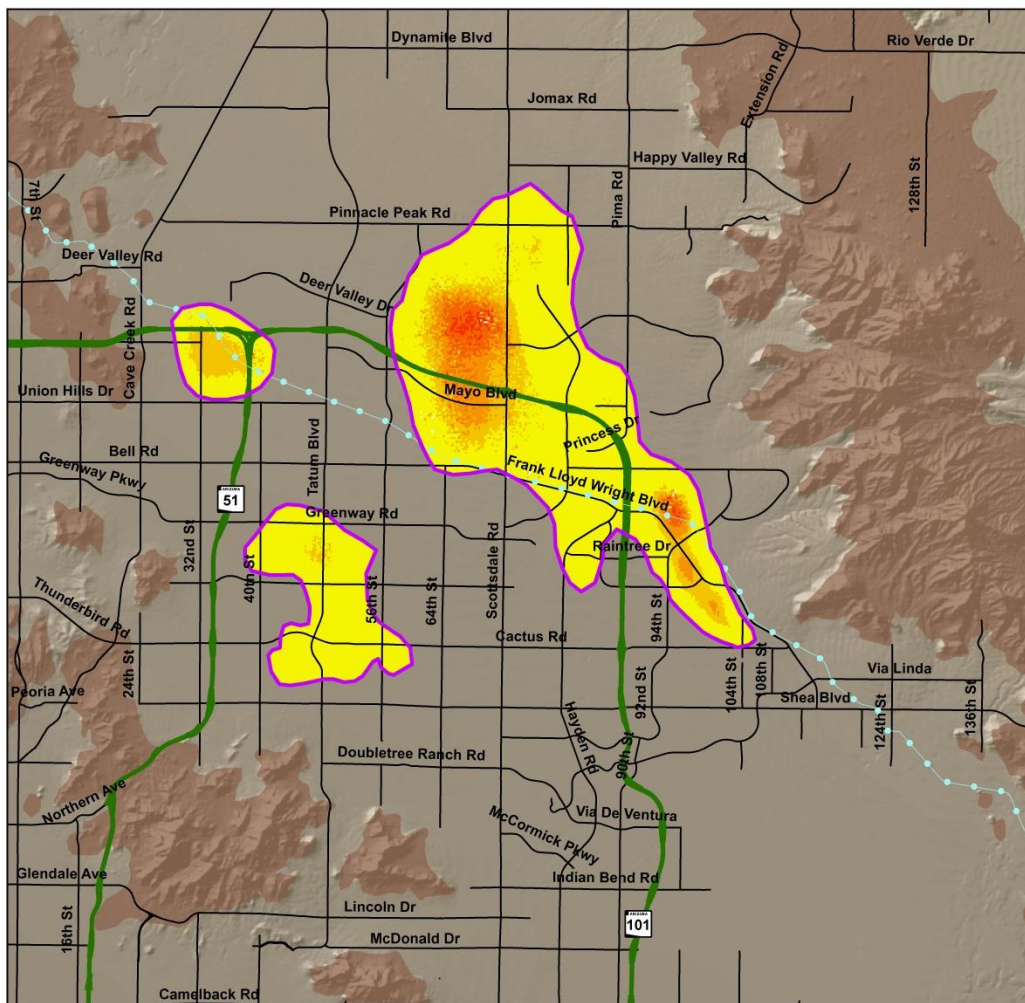




# ADWR InSAR Program

## Northeast Phoenix/Scottsdale 2010-2013 map

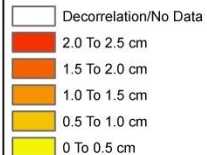
Land subsidence as high as 2.5 cm in  
3-years



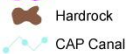
Land Subsidence in Northeast Phoenix and Scottsdale Areas  
Based on ADWR Radarsat-2 InSAR Data  
Time Period of Analysis: 3.0 Years 05/08/2010 To 04/22/2013

05/08/2010 To 04/22/2013

### Subsidence



Subsidence Feature

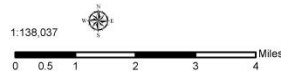
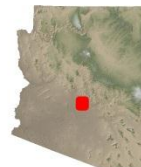


### Highways and Interstates



Note! Colors assigned representing differing amounts of subsidence apply to this map only. Color codes may vary for other maps

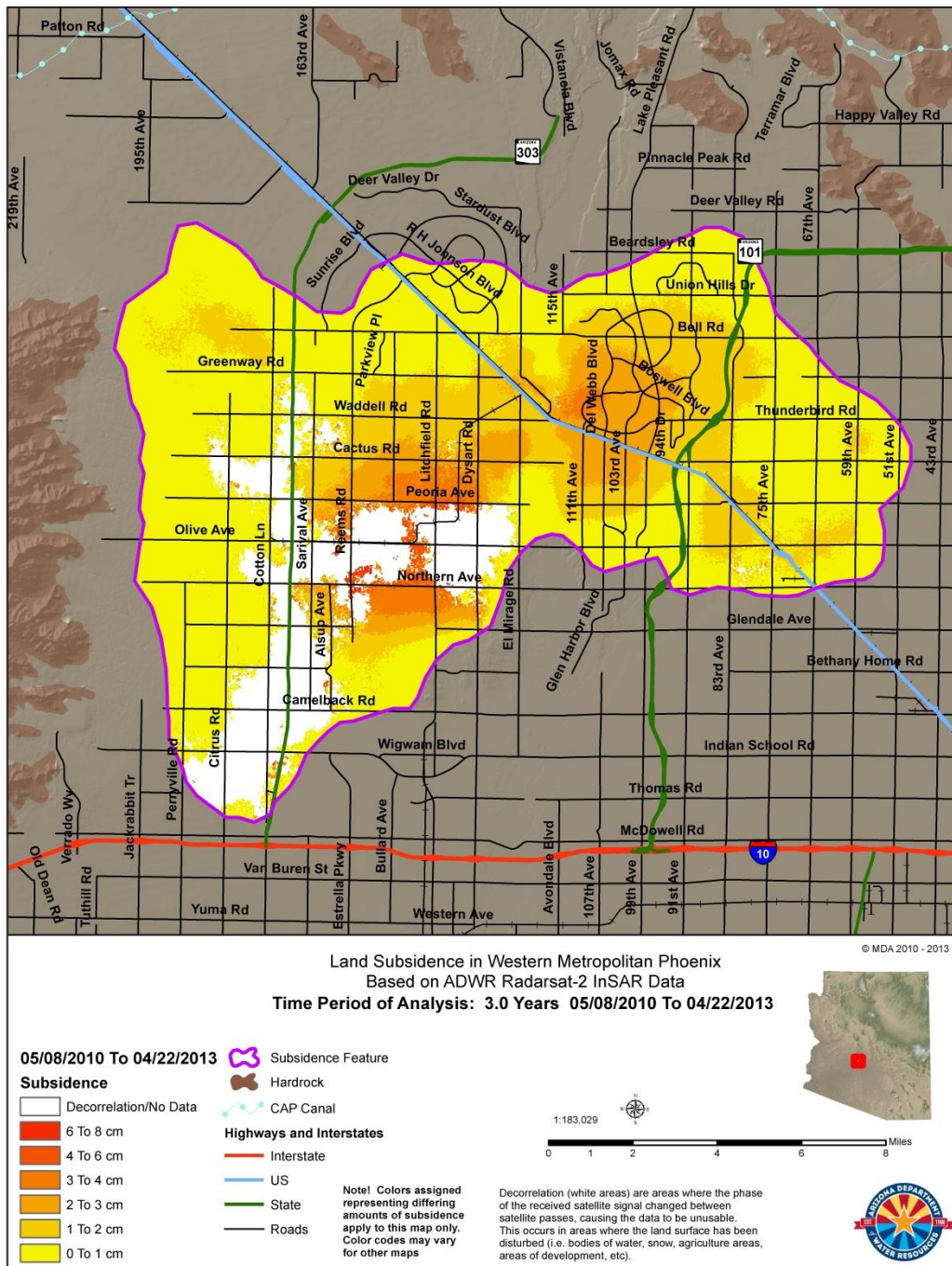
Decorrelation (white areas) are areas where the phase of the received satellite signal changed between satellite passes, causing the data to be unusable. This occurs in areas where the land surface has been disturbed (i.e. bodies of water, snow, agriculture areas, areas of development, etc).



# ADWR InSAR Program

## West Valley 2010-2013 map

Land subsidence as high as 8 cm in 3-years

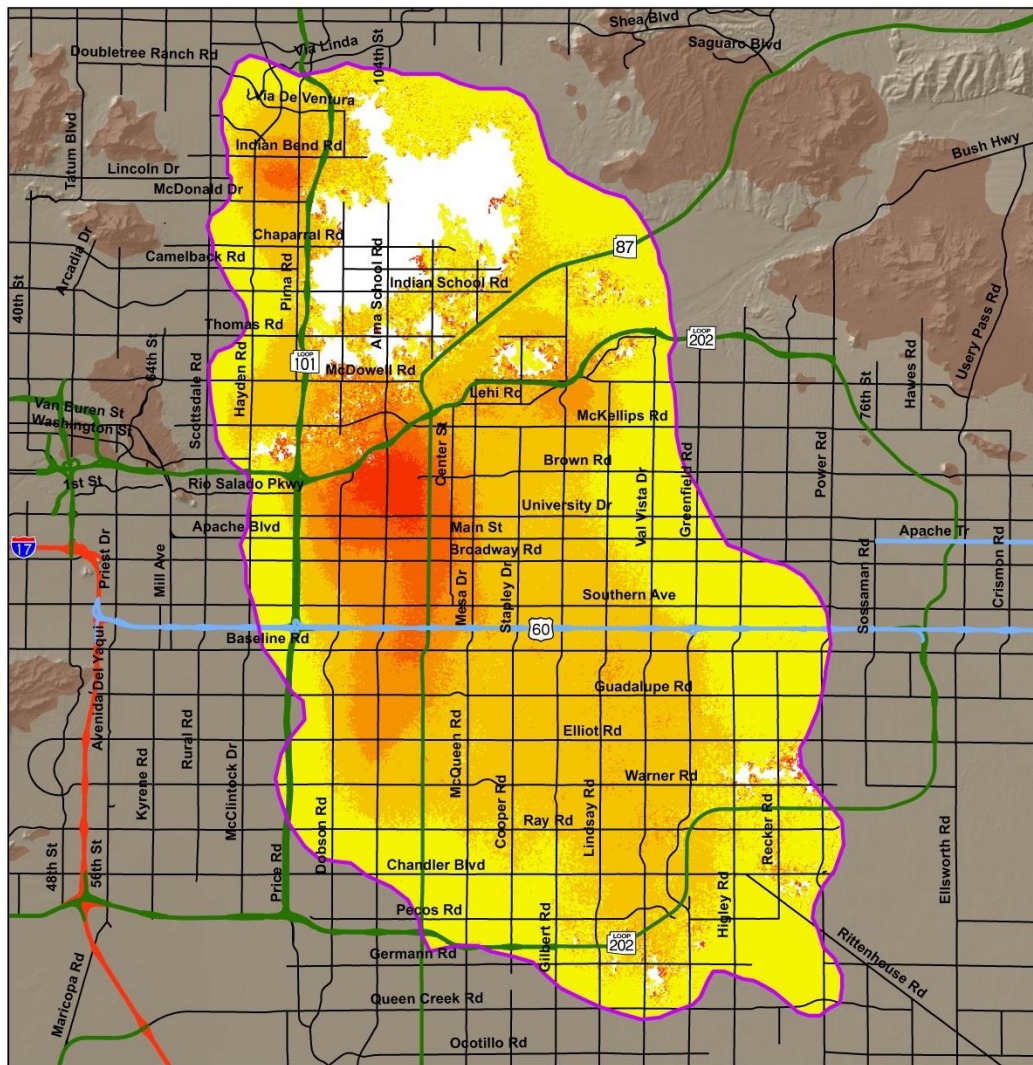




# ADWR InSAR Program

## East Valley 2011-2013 map

Land subsidence as high as 2.5 cm in 2-years



Land Subsidence in the Eastern Metropolitan Phoenix  
Based on ADWR Radarsat-2 InSAR Data  
Time Period of Analysis: 2.0 Years 11/18/2011 To 10/07/2013

© MDA 2011 - 2013

11/18/2011 To 10/07/2013

### Subsidence



Subsidence Feature

Hardrock

Highways and Interstates

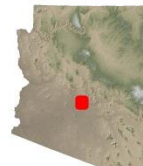
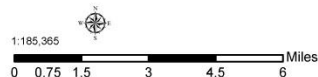
Interstate

US

State

Roads

Note! Colors assigned representing differing amounts of subsidence apply to this map only. Color codes may vary for other maps.



## **The Future of ADWR's InSAR Program**

- ADWR has the largest State operated InSAR program in the U.S. and will continue to collect InSAR data through out State.
- ADWR will continue to work with it's InSAR cooperators and stakeholders, providing land subsidence products for their own monitoring, modeling, mitigation, and planning needs.
- ADWR will continue to update land subsidence maps on it's website each spring using the most recent InSAR data.



# Questions?

Brian D. Conway

[bdconway@azwater.gov](mailto:bdconway@azwater.gov)

602.771.8667



*NASA UAVSAR Platform on  
a Gulfstream III Aircraft*

*Image Courtesy of NASA*